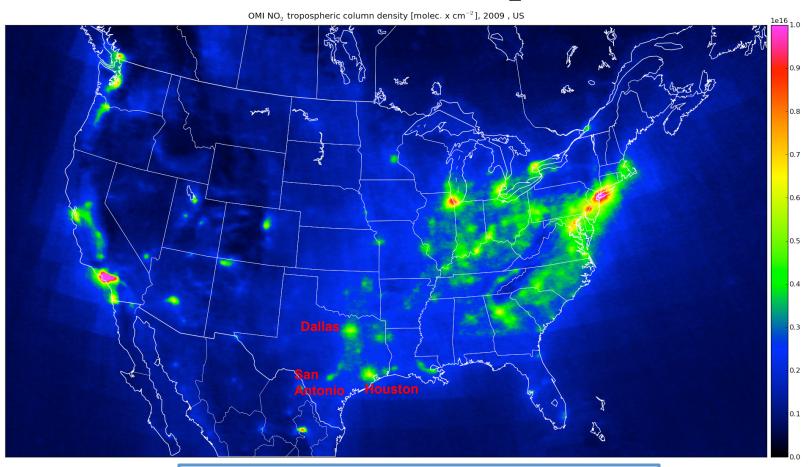
ARSET

Applied Remote SEnsing Training





Aura/OMI NO₂



OMI-derived tropospheric NO₂ columns track NO₂ pollution near the surface, which is an important precursor of urban smog.

Hyper-spectral Instruments

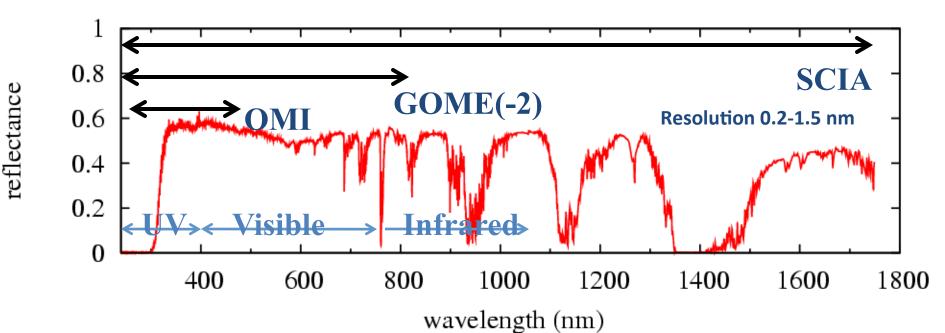
Satellite UV-visible spectrometers

GOME	ERS-2	240 – 800 nm

SCIAMACHY Envisat 240 – 1750

OMI EOS-Aura 270 - 500 nm

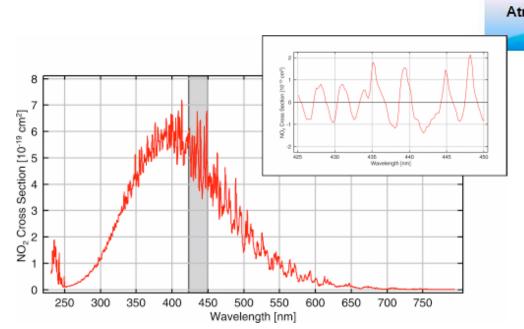
GOME-2 Metop-A 240 – 800 nm



Tropospheric NO₂ retrieval method: In a Nutshell

STEP 1: The NO₂ column densities are retrieved by first fitting the spectroscopic features in the measured radiances to get slant columns.

Total NO₂ Slant Column density: S



Atmosphere

Column

Sea

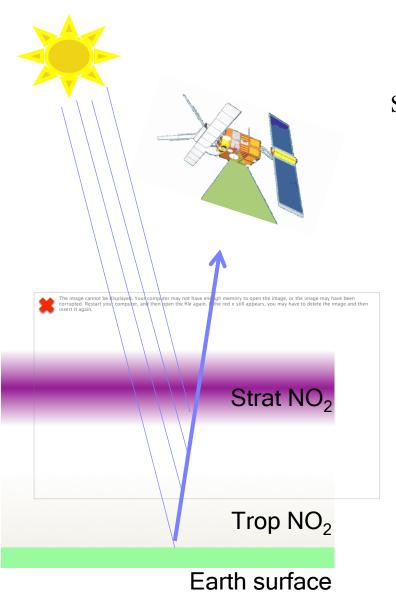
Land

The 405-450 nm wavelength region is chosen because of the large structures in the NO₂ cross-section, and of the limited interferences with other absorbers.

OMI

STEP 2: Remove stratospheric part: S_{strat}

→ Tropospheric NO_2 slant column density: $S_{trop} = S - S_{strat}$



Stratosphere NO₂ columns are estimated from models.

Table 1. Albedo, terrain pressure, and NO_2 vertical profiles in each of the three satellite column NO_2 retrievals studied here.

	NASA Standard Product	KNMI DOMINO Product	This work BEHR Product
Albedo	*10/04-02/09: GOME derived, 1° × 1°, Monthly; 02/09-current: OMII derived, 0.5° × 0.5°, Monthly	*10/04-02/09: GOME derived, 1° × 1°, Monthly; 02/09-current: OMI derived, 0.5° × 0.5°, Monthly	MODIS MCD43C3, 0.05° × 0.05°, 16 day average every 8 days (averaged to OMI pixel)
Terrain Pressure	SDP Toolkit 90 arcsec DEM map (pressure @ center of OMI footprint)	TM4 model, 3° × 2° resolution, interpolate four adjacent cells to the center of the OMI pixel	GLOBE 1 km × 1 km topographical database (averaged to OMI pixel)
NO ₂ Profile	GEOS-Chem 2° × 2.5°, Annually	TM4 model, 3° × 2° resolution, Daily, interpolate four adjacent cells to the center of the OMI pixel	WRF-Chem 4 km × 4km, Monthly (averaged to OMI pixel)

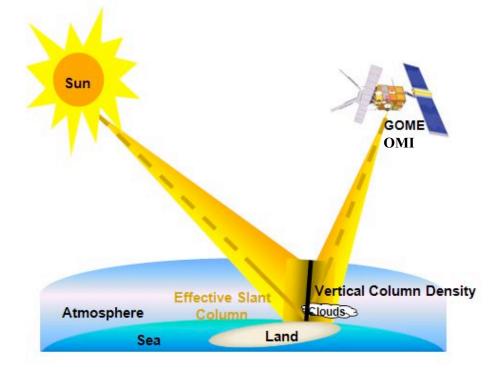
STEP 3: Convert slant column to vertical
 → Tropospheric NO₂ column

$$V_{trop} = S_{trop} / A_{trop}$$

V → Vertical column density
 S → Slant column density
 A → Air mass factor

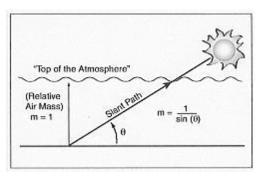
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Air Mass Factor depends on a variety of parameters such as:

- Wavelength
- Geometry
- Clouds
- Aerosol Loading
- Surface Albedo



The major improvements in NASA NO₂ product

(1) New stratospheric and tropospheric air mass factors:

- Monthly a priori NO₂ profiles (NASA GMI model)
- High resolution LUT of scattering weights (local AMF)
- Improved OMI derived surface albedo [Kleipool et al]

(2) Improved striping correction

- Based on 5 orbits between latitudes 30° S and 5° N
- Cross-track locations with strong stripes excluded from averages

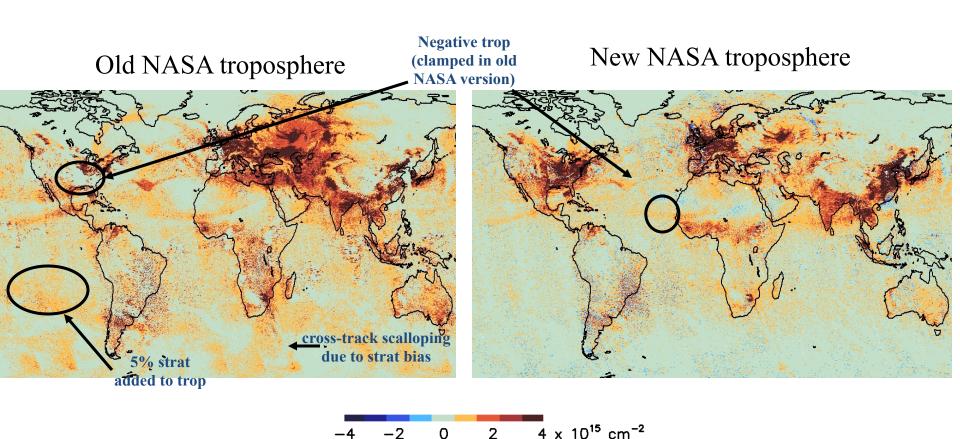
(3) New stratosphere–troposphere separation scheme

Changes affecting data usability:

- (4) Adding averaging kernel profiles
- (5) Simplified data definitions- e.g. Strat, Trop and Total

Comparisons of tropospheric NO₂ retrievals 2005-3-21

- •All retrievals show enhanced Trop. NO₂ in polluted regions.
- Biases in the strat. can be aliased as trop. "features" (e.g. cross-track scalloping, and negative trop. values where the strat. is too high).
- The old NASA SP enhances the troposphere in "clean" regions with addition of 5% strat. to the trop. columns. It also clamps negative trop. at zero.



Monthly mean tropospheric NO₂ differences (2005 data)

(NASA NextGen) – (old NASA)

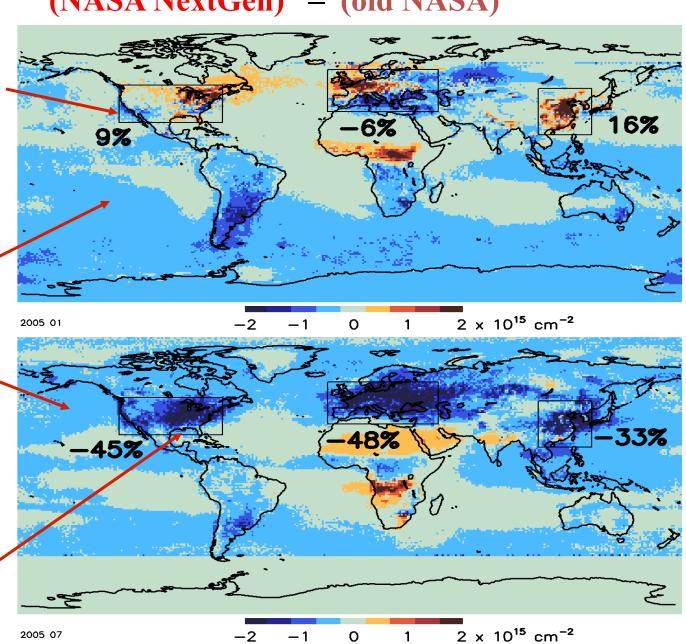
New NASA is near or slightly higher than old in winter polluted regions.

January

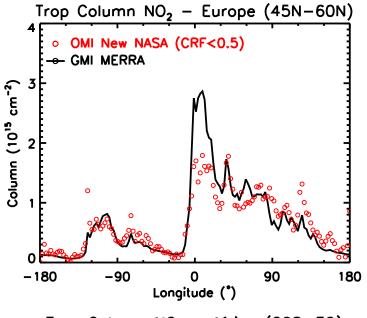
Old NASA had high bias in clean regions, due to (1) addition of 5% strat to the trop, and (2) lack of negative values.

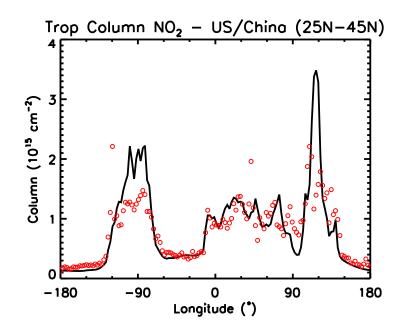
July

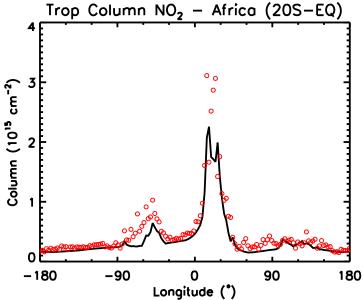
Old NASA was much too high in summer polluted regions. New NASA trop columns are more realistic



New NASA trop NO₂ comparisons with GMI: Jul 2007





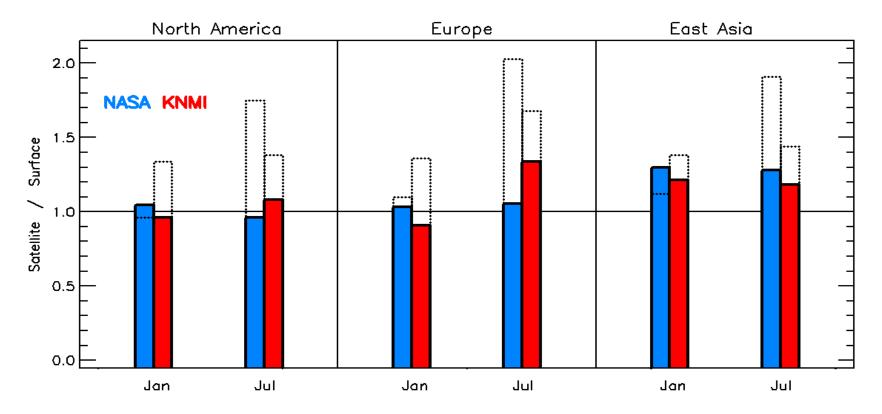


 Zonal profiles in selected latitude bands corresponding to significant pollution sources

Ratio of satellite (top-down) to surface (bottom-up) NO₂ emissions estimates

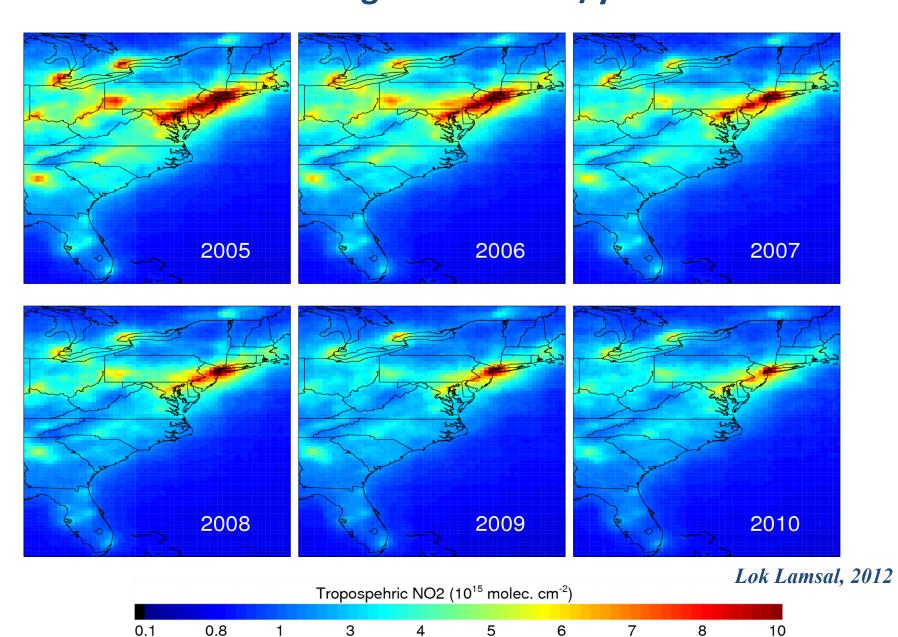
Monthly mean regional OMI tropospheric columns relative to current surface inventories:

NASA OMNO2 product (NextGen = blue, older version= open box)
KNMI DOMINO product (Version2 = red, older version= open box)



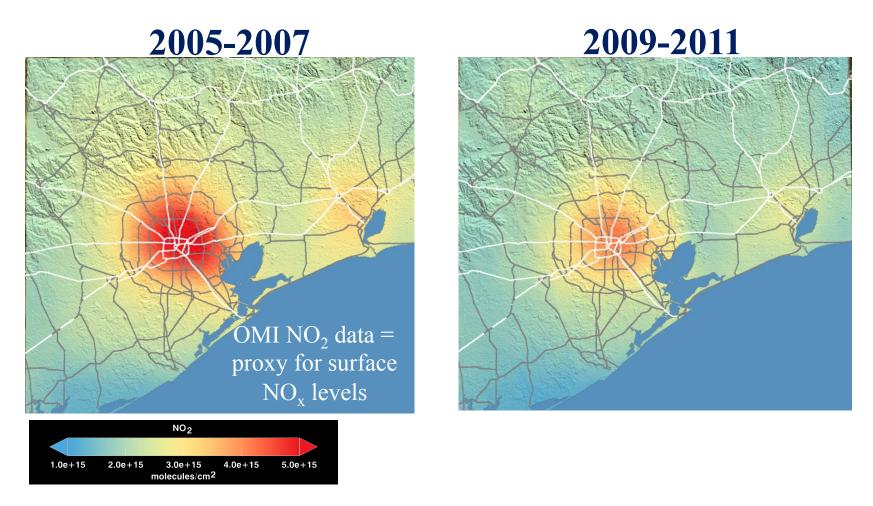
^{*} from Lamsal et al., 2010, figure 9

Re-processed OMNO₂ Standard Product (SP V2.1) shows declining trends ~10%/year



OMI NO₂ data: Implications for air quality applications

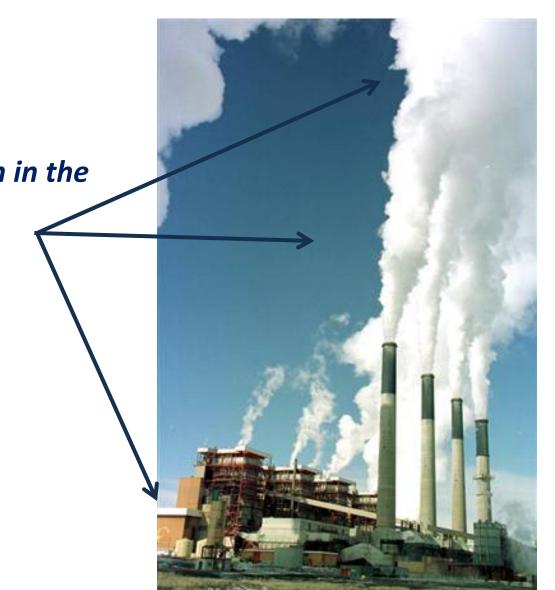
Bryan Duncan, Yasuko Yoshida, Lok Lamsal, NASA OMI Retrieval Team NASA Goddard Space Flight Center, Greenbelt, MD



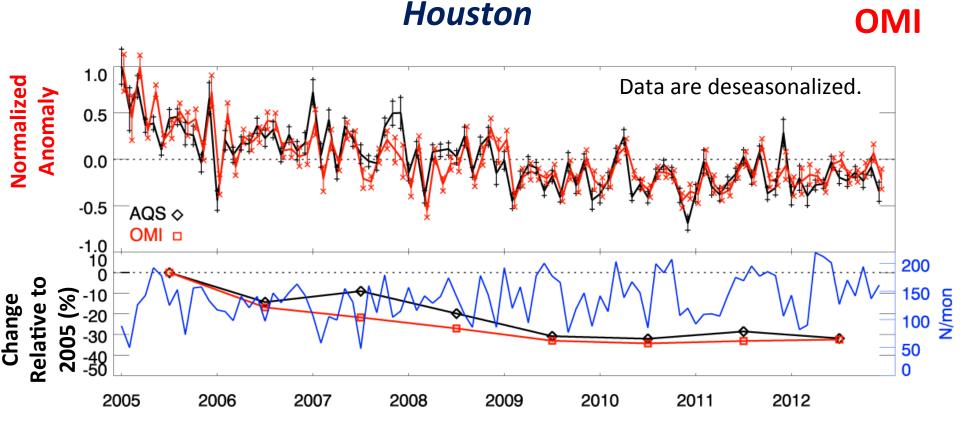
AQAST STM, Rice U., Houston, TX,

OMI detects pollution in the free troposphere and boundary layer.

How does OMI NO₂ data compare to surface observations?



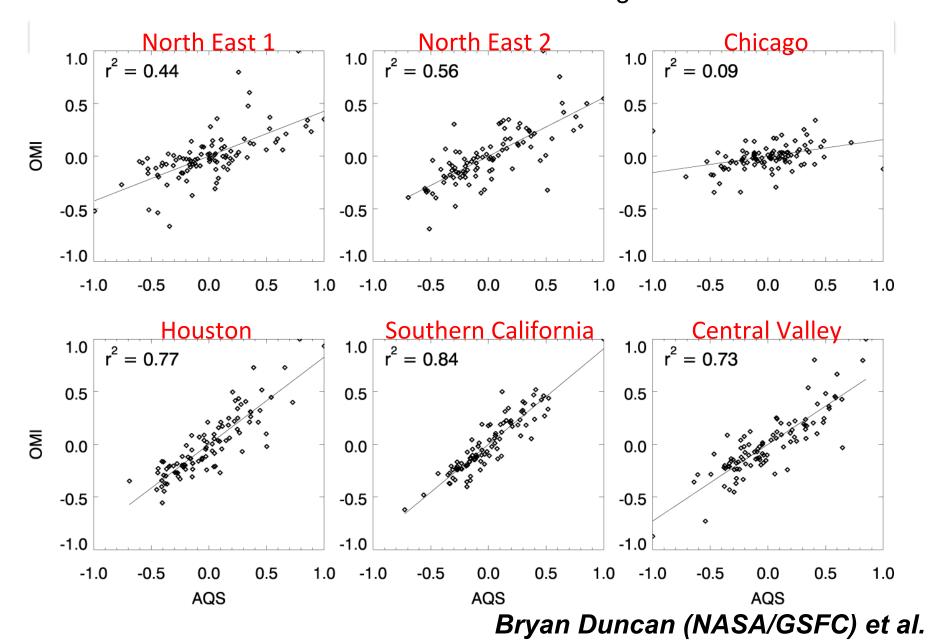
Time series of EPA/AQS and OMI NO₂



Bryan Duncan (NASA/GSFC) et al.

AQS

Correlation of monthly mean AQS & OMI NO₂ Anomalies Correlation worsens with increasing latitude.



Bryan Duncan (NASA/GSFC) et al. – AQAST Team member

Main Conclusions

Aura OMI NO₂ data can be used to

- 1. monitor emissions from power plants and
- 2. demonstrate compliance with environmental regulations.
- 3. careful interpretation of the data is necessary.

OMI Tropospheric Column NO₂ for AQ appl.

- Two Separate Algorithms
 - NASA/GSFC "Standard Product"
 - Level 3 data (cloud screened) coming soon to GES-DISC
 - Data Short name = OMNO2d
 - 2. KNMI (Royal Netherlands Meteorological Institute) DOMINO (Near-Real Time) Product
 - Level 2 data and images available from KNMI and TEMIS.
 - Data Short Name = OMDOMINO
 - http://www.temis.nl/airpollution/no2.html
 - Includes data/images from European Satellite instruments: GOME, GOME-2, SCIAMACHY

GSFC Standard Product for AQ Applications

OMI L3 product is based on the enhanced algorithms has been reprocessed.

Data Set Short Name = OMNO2d

Product Level = 3

Begin Date = October 1, 2004

Resolution = 0.25°lon x 0.25°lat

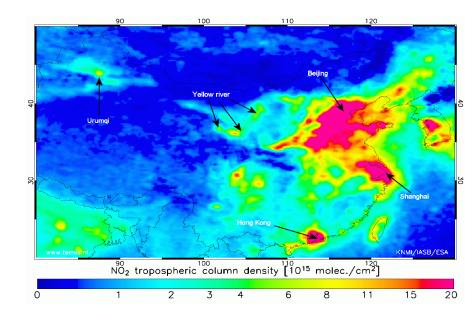
Version = 003

Cloud-screened best observation

Production Frequency: Daily

Granule (File) Coverage: 15 orbits

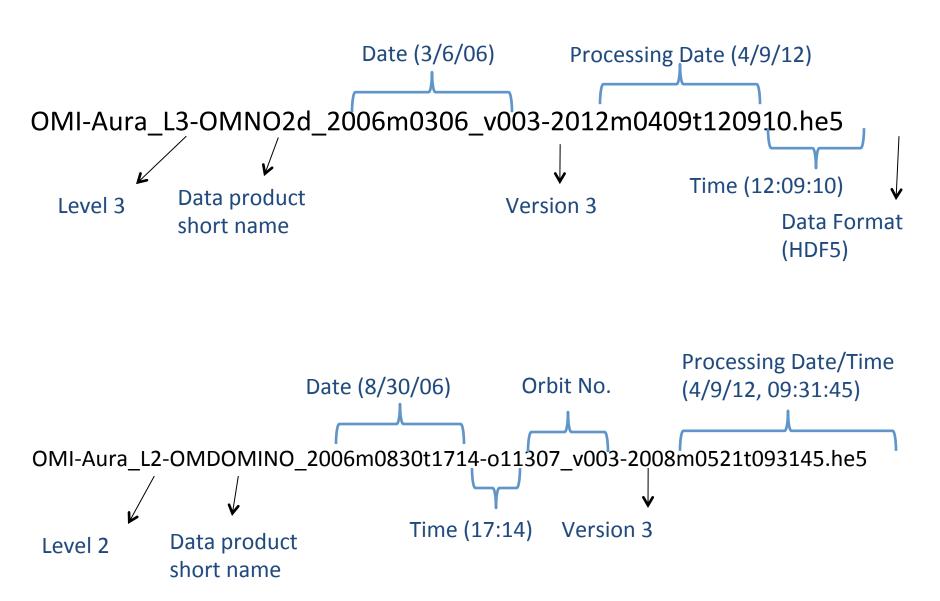
File Size (Approx): 2.5 MB



Data here:

http://disc.sci.gsfc.nasa.gov/Aura/data-holdings/OMI/omno2d_v003.shtml

File Name Convention



Data Access

TEMIS (Tropospheric Emission Monitoring Internet Services)

- KNMI DOMINO Near-Real Time NO₂ Product
 - Level 2
 - HDF format only
 - Google Earth KML files

GES-DISC (Goddard Earth Science Data and Information Services Center)

- Level 2, L2G, Level 3 (OMNO2d)
- HDF and NetCDF
- Documentation

AVDC (Aura Validation Data Center)

- Level 3 (OMNO2d)
- HDF, ASCII, KML formats
- Daily and monthly data and Images

GIOVANNI – an interactive visualization tool

- L2G, Level 3 (OMNO2d)
- HDF, ASCII, KML for Google Earth
- Subsetting available



http://www.temis.nl/airpollution/no2col/no2regioomi_v2.php

Regional Tropospheric NO2 columns from OMI



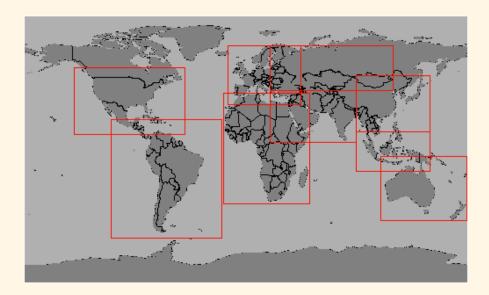
NO2 observation for:

submit

Info on data anomalies

Access the archive of regional Tropospheric NO2 columns based on OMI measurements by selecting a region and a date in the menu on the left. The location of the available regions is shown in the figure below. If you click on either of these regions, you get the image for that region of the last available date.

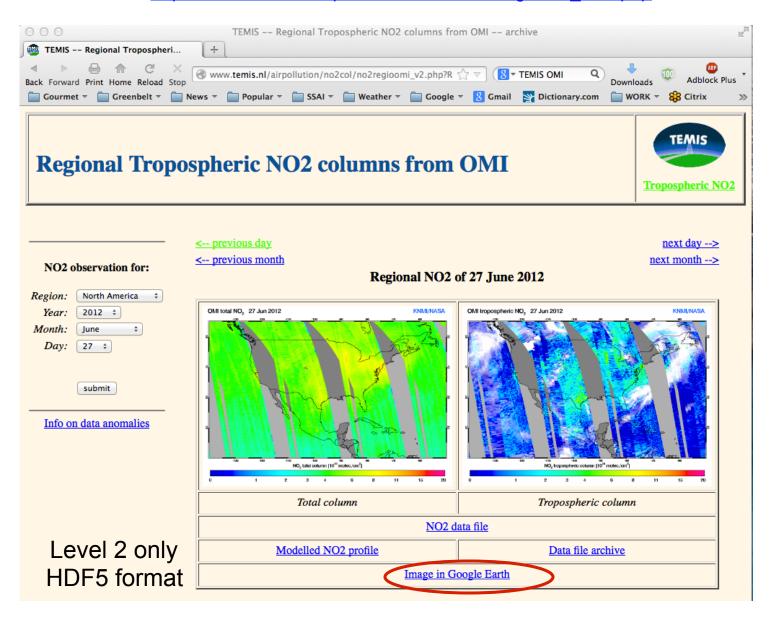
Data is available for the dates 01 October 2004 to 31 January 2014.



OMI DOMINO Tropospheric NO₂

Global Near Real-Time OMI NO₂ Tropospheric Column from KNMI

http://www.temis.nl/airpollution/no2col/no2regioomi col3.php



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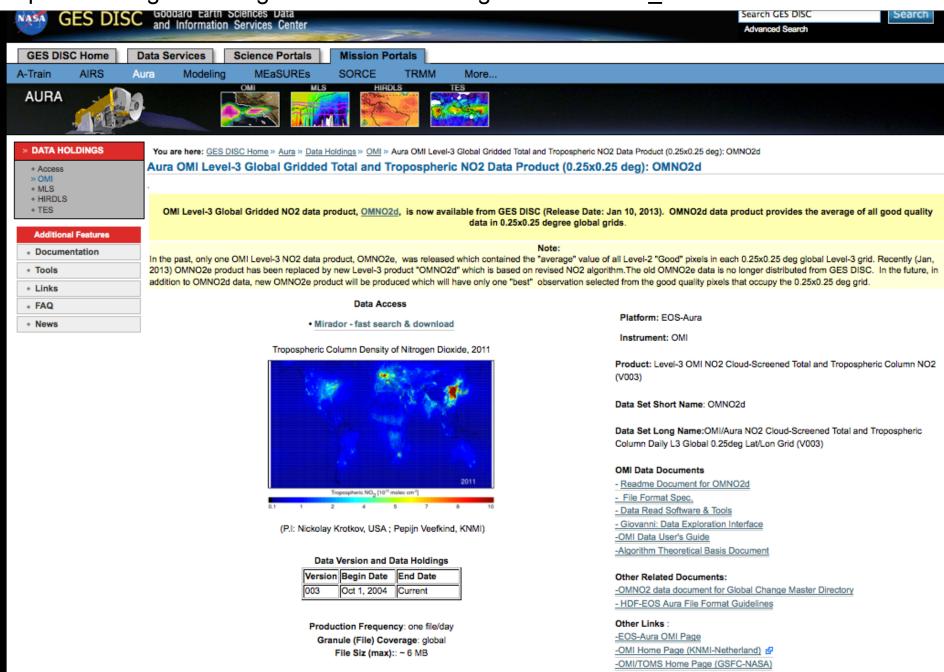
AVDC (Aura Validation Data Center)

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GIOVANNI – An interactive visualization tool

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- Subsetting available

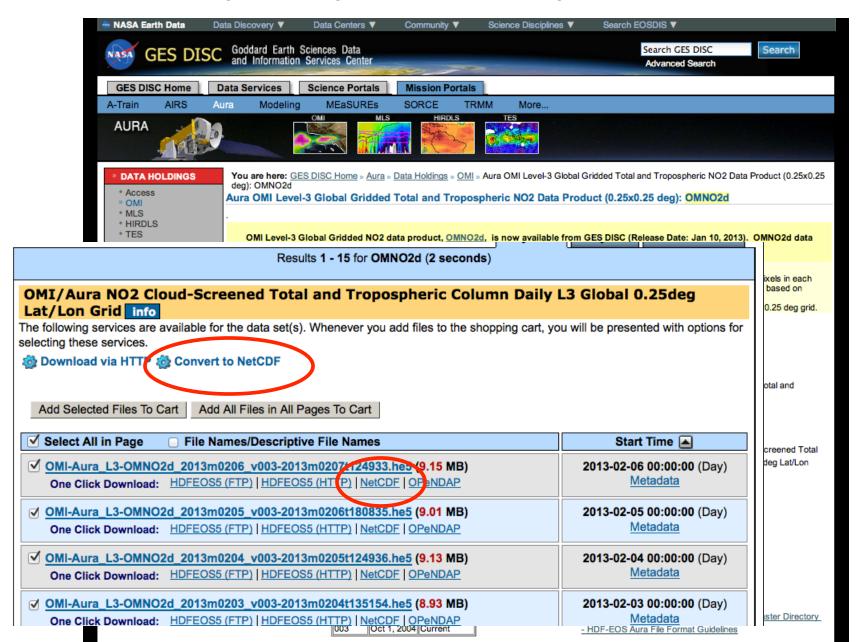
http://disc.sci.gsfc.nasa.gov/Aura/data-holdings/OMI/omno2d_v003.shtml



-Aura Validation Data Center (AVDC)

NASA GES-DISC - OMNO2d, Level 3, 0.25 Degree Product

http://disc.sci.gsfc.nasa.gov/Aura/data-holdings/OMI/omno2d_v003.shtml



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GES-DISC (Goddard Earth Science Data and Information Services Center)

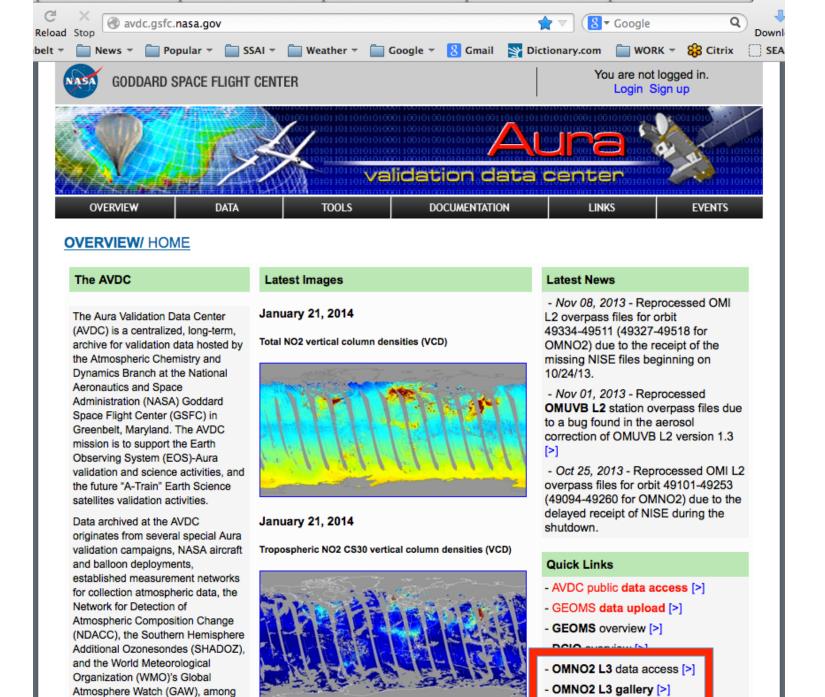
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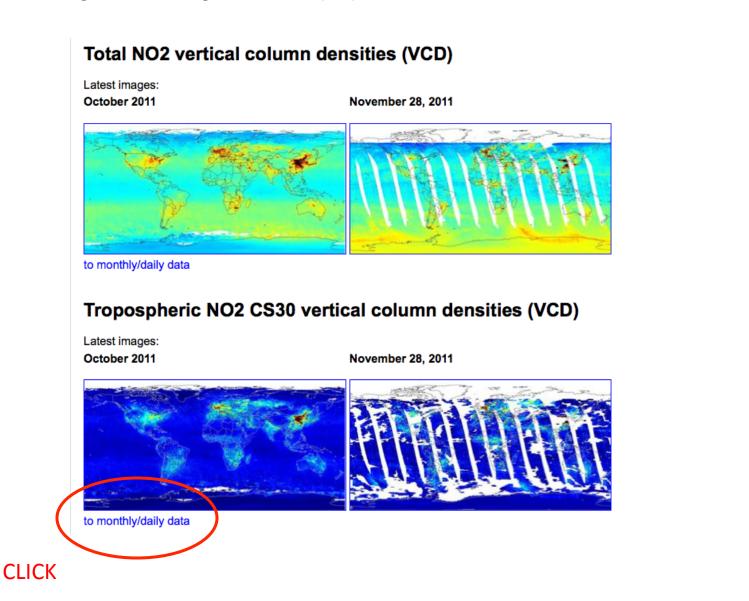


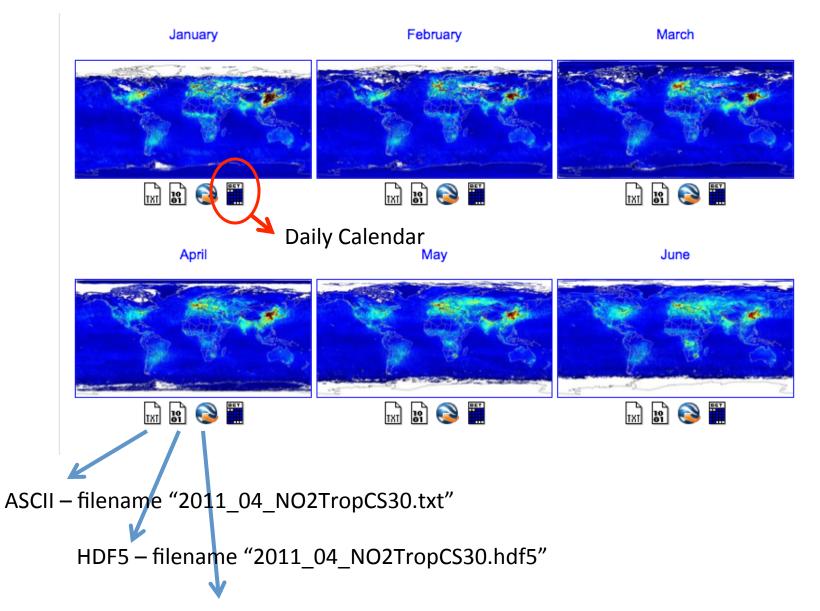
others.

(S. T.



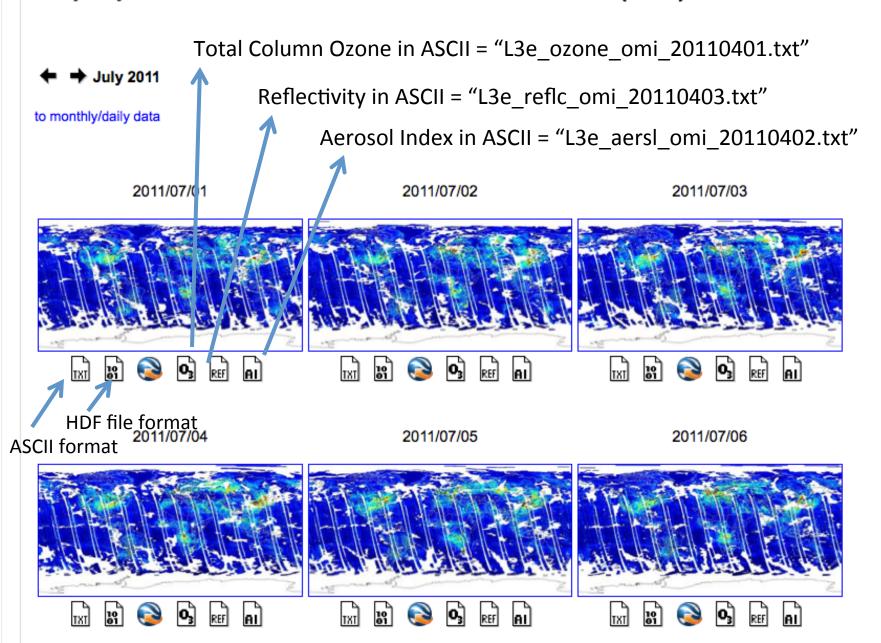
AVDC - Aura Validation Data Center http://avdc.gsfc.nasa.gov/index.php?site=705441739





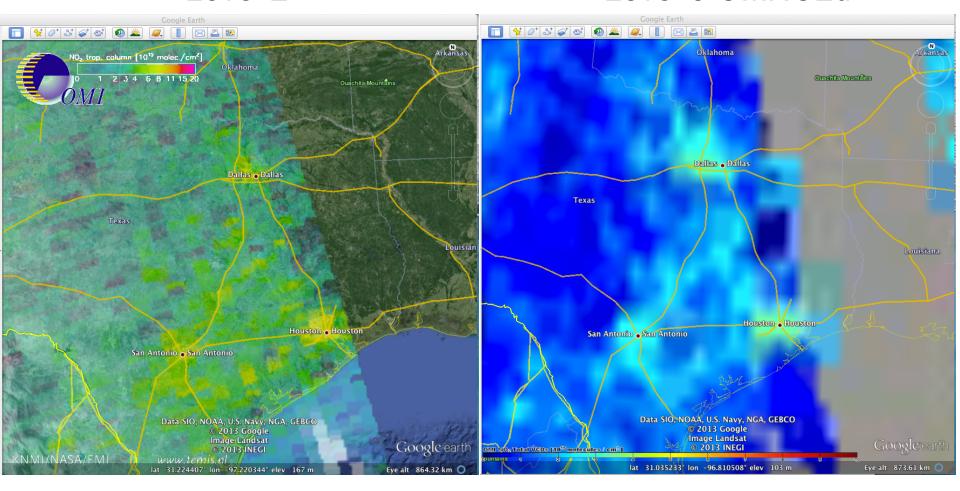
KML – filename "EOS-Aura-OMI-OMNO2-L3_2011_01_NO2TropCS30.kml"

Tropospheric NO2 CS30 vertical column densities (VCD)



KNMI DOMINO Product Level 2

GSFC Standard Product Level 3 OMNO2d



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http://gdata1.sci.gsfc.nasa.gov/daac-bin/G3/gui.cgi?instance_id=omi

